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BOOK REVIEWS

Health and Ecological Implications of Radioactively Contaminated Environments

(Proceedings of the Twenty-Sixth Annual Meeting of the National Council on Radiation Protection and Measurements (NCRP), 4-5 April, 1990)

NCRP: Maryland, USA (1991)
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The whole world has become health and ecology conscious. It is, therefore, no surprise that NCRP chose "Health and Ecological Implications of Radioactively Contaminated Environments" as the theme for its 26th annual meeting. The topic is of great public and professional interest as was mentioned by Warren K Sinclair, President of NCRP in his opening remarks. This is also true for our country with an ever increasing presence of radioactivity and other radiation sources as well as other pollutants in our midst.

The meeting was constituted into five sessions viz. (I) Contaminated sites, (II) Human Health Implications, (III) Remediation, (IV) Panel discussion and (V) Summation. Session I had five speakers, session II had three and session III had two speakers.

Session I

1. An overview of Sites Contaminated by Radioactivity

Merril Eisenbud

Three types of sites viz. (i) places used during the early part of this century, to produce compounds of radium or thorium to manufacture luminous clock and instrument dials, (ii) the chain of uranium extraction plants used during and shortly after World War II, and (iii) plants and laboratories that comprise research and weapons production complexes of the Department of Energy (DOE, USA) even today. While the main focus of Eisenbud's talk was on DOE's activities, he did show concern over the large sums of money spent in collecting and disposing off soil contaminated with Ra-226 and huge amount of money planned to be spent on decontaminating uranium production plants, both mainly because of public pressure.

Eisenbud appears to be unhappy over the current widespread concern in the USA, in respect of the contamination in the complexes of the DOE. He is of the opinion that while the DOE has been neglectful of controlling chemical contamination, partly because of permissible limits for chemical pollutants have been slow to develop, the control and documentation of measurements of radioactive contamination has a long tradition aided by organisations such as the International Commission on Radiological Protection (ICRP) established 1928, the National Council on Radiation Protection and Measurements (NCRP), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), established in 1955. A major reorganisation of DOE and 30-year cleanup programme involving billions of dollars of expenditure has been ordered. However, Dr

Eisenbud feels that much of the huge cost of cleanup will be for reasons other than radioactive contamination. In support of his contention he quoted from a 1989 report of the Environmental Protection Agency (EPA) wherein the releases to the atmosphere from 27 major facilities of DOE are summarised. It was estimated that among the 67 million people who live within 80 km of the facilities, death from radiation induced cancers would occur at a rate of 0.02/y, whereas natural radioactivity would be expected to result in several thousand fatal cancers per year and even naturally occurring radionuclides emitted from the stacks of coal-fired utility power plants result in 0.4 excess cancers per year among the 240 million people in the United States. Even the most criticised Savannah River Site contributed (in 1986) only about 500 person-rem to the 550,000 people who live within 80 km of the site.

For persons engaged in public information and increasing awareness programmes, it would be instructive to note the following observations of Eisenbud :

(1) What frightens the public is that radioactivity is present—not how much is present, or how it relates to the levels of radioactivity present naturally. (2) The general public finds it difficult to think about the subject of radioactive contamination in quantitative terms. (3) The public seems to have different perception of danger depending on whether the source of radiation exposure is natural or unnatural. (4) Some people who will willingly imbibe water and breathe air containing higher than normal levels of radioactivity will not tolerate any unnatural radioactive fallout.

This kind of perception has led to expensive waste disposal practices, opined Eisenbud. He also deplores the role of media in influencing public perception by wrong or exaggerated projection of risks and by featuring claims of individuals who believe their health problems have resulted from exposure to effluents from DOE facilities without bothering to note that the doses from these effluents are immeasurably small. The society appears to be making qualitative judgements disregarding the existing guidelines for permissible limits of exposure.

In this reviewer's opinion, the practitioners of radiological protection invariably forget that radiation exposure whether natural or manmade is an abstraction in the sense that one cannot experience it. It has got to be demonstrated with the help of instruments. There is no experience of living with or tolerating radiological risks like other tangible risks. The fear of radiation is the phobia of the unknown and must be minimised by relating it to experience such as that of chest x-ray rather than natural background radiation alone. Only those who have used and worked with radiation, have seen its effects on instruments know its presence. They understand it and are not afraid of it. It is very difficult to allay the fear of the unknown and the unseen.

2. Legal Standards Concerning Health and Ecological Implications of Radioactively Contaminated Environments
Thomas F Dorian

Mr Dorian, a lawyer by profession, appears to have read the public mind correctly in

advocating that in the real world we should not analyse the technical, legal, political and financial issues apart from each other and without adding the public opinion and perception issue. He draws attention to the entry in the DOE's Five Year Plan on Environmental Restoration and Waste Management: "As the public's servant, and under the public scrutiny, DOE must fulfil its mandate: public wants and demands not only more environmental protection but also more understandable information and involvement with plans and progress toward achieving environmental compliance and waste cleanup". He endorses Alvin Weinberg's view that the best we can hope for is to convince the "skeptical elite" and thereby influence the broader public.

We all know how Governments work, particularly in relation to making legislation. Usually it ends up in a plethora of laws, often disparate and inconsistent with each other. Therefore Mr Dorian calls for clear, understandable, consistent, harmonised, accountable legal standards (both outside DOE in terms of legislative and federal vegulatory requirements and inside DOE in terms of its own cleanup regime) against which DOE can measure its cleanup efforts.

There is always problem with Departments who have only an internal regulatory regime and are not subjected to a checkup by an outside independent agency. A five-member Defence Nuclear Safety Board created by Congress in 1988 to provide an independent overview of DOE's defence facilities reported a large degree of variability, lack of unformity and specificity and even uncertainty in DOE's orders for maintaining health and safety at its facilities. Mr Dorian also draws attention to the inextricable difficulties caused by having to satisfy several agencies both federal and state level with overlapping goals but differing standards. He also lists the multiplicity of laws already existing. Hence, the need for harmonisation and consistency.

Mr Dorian makes several suggestions to remedy the situation over a period of time, but most important, perhaps, is the one requiring DOE to produce an annual "report card" to Congress and the public about its risk reduction efforts and costs. Worth emulating by all such agencies!

3. Sources

Leo P Duffy

Contamination, Cleanup, legal problems, but what are the sources of contamination and what are their ecological implications? This is what the DOE's Environmental Restoration and Waste Management Five-Year Plan attempts to codify : known and unknown contaminants and releases to the environment including uranium isotopes, plutonium isotopes, fission products, mine tailings, uranium mill tailings, radioactive gas and billions of gallons of low-concentration of aqueous radioactive solutions. Mr Duffy of DOE admits that there are examples of these problems at all DOE sites, Savannah River, Oak Ridge, Idaho, Hanford and others and the problem is huge. He points out that the methods of

discharge and storage were not good and should have been terminated and are being terminated now. He also calls for a strategy for geologic disposal of transuranic materials. He advocates to stop gloom and doom, hand wringing, finger pointing, and historical hindsight.

Mr Duffy is irritated that there is no reliable scientific Ombudsman to speak without bias and prejudice for public good and that technical jargon with unclear definitions exists within the radioactive nomenclature. He also laments that there are several sources of inflammation such as the dangers of plutonium or the amount of plutonium required to make a bomb, TMI-2 and Chernobyl being described as Siamese twins, and so on. Finally he points out that the Fourth Estate has a responsibility to educate the public on issues that affect their lives and not merely report news events.

Media reporting is a source of irritation. It makes bland statements regarding radioactivity without giving the relevant information as the degree of contact, duration of exposure, or bodily intake. There are a number of factors which determine the harm due to radioactive releases and unless these are discussed in simple understandable language, public is sure to be misinformed. Mr Duffy rightly says, and there is a lesson for everybody in this, that the need today is public and scientific co-ordination to prevent expedient, foolish solutions and development of environmental standards that are achievable and cost effective.

4. A Summary Approach to Better Understanding Groundwater Problems and Evaluating Long-Term Environmental Consequences

R W Nelson

Radioactive discharges at ground levels, in pits or trenches are likely to result in subsurface contamination. Protecting the quality of groundwater involves maintaining its quality for future use and remediating past subsurface mistakes. Mr Nelson outlines a summary approach which has developed in groundwater hydrology discipline over the past two decades. The vital information is contained in the contaminant arrival distributions which are needed for quantitatively evaluating any subsurface contamination problem.

1. Determine the outflow boundary of contaminated ground water that may now or will in the future interface with the accessible biosphere.

2. Provide the contaminated water outflow location/water arrival time distribution for each outflow boundary in requirement 1 above.

3. Provide the contaminated water outflow loation/water arrival quantity distributions for each outflow boundary in requirement 1 above.

4. Provide the specific outflow location/arrival time and outflow location/arrival quantity distributions for each individual chemical or biological constituent of environmental importance in the contaminated water in requirement 1, 2 and 3 above.

5. Determine the concentration and mass of each contaminant constituent that will interface with the accessible biosphere. This is accomplished through use of the contaminant arrival distributions from requirements 2, 3, and 4 above.

Mr Nelson also discusses each of these distributions in detail.

5. Ecological Aspects of Environmental Assessment of Contaminated Areas

William L Templeton

Radioactive or other material discharged into the environment are carried to vegetation, animal and man through processes that occur in the ecological pathways. Definitive models exist for these pathways both terrestrial and aquatic. These models involve a number of factors in translocation, weathering, standing crop biomass, soil build-up time, etc. Then, there are concentration factors in animal products directly or through animal feeds and man. Similarly, in the aquatic pathway of radionuclide transfer, processes such as dilution, dispersion, adsorption on sediments, assimilation by aquatic biota, etc. are involved.

Mr Templeton after describing these, emphasizes, very rightly, the importance of uncertainties and model validation. Usually, the models are conservative and overestimate. But with increasing emphasis on restricting release and dose to levels as low as reasonably achievable (ALARA), importance is being placed on deliberate conservatism in assessment calculations. But, concentrations in the environment are so low that demostrating compliance by environmental measurements is expensive and difficult. Therefore, reliance on models will be mandatory and to avoid under-estimating, by not being conservative, would require good understanding of the magnitude of uncertainty. Model validation, being very difficult, a method using parameter imprecision or sensitivity can be used. In this method, the variability associated with each model parameter is estimated to ascertain the influence of the combined variability of all model parameters on the model output. The Chernobyl accident provided an opportunity for model validation and this was seized by the Swedish National Institute of Radiation who organized an international group for Biospheric Model Validation Study (BIOMOVS).

The model predictions for total deposition were within a factor of 2 and 1.5 of the observed values for iodine (6 sites) and cesium (5 sites) respectively, while the predictions for wet deposition were within an order of magnitude. It is worth noting that all grass-milk transfer factors for iodine were well below the generally accepted value of 1×E-2. The average for all locations was 2.6×E-3.

Mr Templeton has made a few other very pertinent remarks. One is on Screening Models so that the costs and efforts are commensurate with the problem at the site. Second, he draws attention to the role plants and animals play in confounding efforts in the remediation of radioactive and mixed-waste through isolation from the environment.

Session II

6. Human Health Implications of Contaminated Sites Risk Estimation

Seymour Jablon

Dr Jablon has discussed the difficult problem of risk estimation from low levels of radiation exposure. These estimates are based on data and models. The data is provided by the A-Bomb survivors and the models are what you think is right for extrapolation from a higher level to a lower level and an absolute comparison or a relative comparison with the natural incidence of cancer! The recent upward estimation of radiation risks is analysed. Dr Jablon compares the lifetime risk estimates for instantaneous exposure to 0.1 Sv (10 rem) as estimated by the committees on Biological Effects of Ionizing Radiation (BEIR) III and V. The estimated risk for leukemia has increased by a factor of 4 in males and 4.3 in females. The increase is smaller, 3.4 in both males and females for other cancers. There are several reasons for this. The estimated does is less in the revised dosimetry because of the neutron component and neutron RBE, dose rate extrapolation factor, and the distribution of age at exposure.

Based on the available data lifetime excess cancer mortality risk estimates to a standard U.S. population are calculated for a continuous exposure of 1 mSv/y to 100,000 persons (BEIR V) as :

	male	female
Leukemia	70	60
Nonleukemia	450	540
Total	520	600
Percent of normal	2.5	3.4

7. Epidemiologic Studies of Radioactively Contaminated Enviroments and Cancer Clusters

John D Boice Jr

Ionizing radiation causes cancer at high doses is well established and accepted. That it causes cancer at low doses is also believed by most persons because of radiobiological considerations and present understanding of cancer induction. However, at low doses it is only probabilistic or statistical and not observed directly. This is determined by extrapolation from the known effects at high doses. Because of the importance of knowing directly the effects of low levels of ionizing radiation, epidemiologic studies are conducted. But, the statistical power of these analyses is low because of the low doses, limited size of the sample and the high background level of the same effects. The estimates tend to be imprecise. Nevertheless, these studies are important and with time their precision will also improve.

Dr Boice describes several such studies and their outcome. He has classified such studies as geographic correlation surveys, analytic studies, and cluster evaluations.

Geographic correlation studies or ecological surveys relate diseases in populations to area characteristics. Dr Boice has discussed published data on such areas :

(1) Colorado—where uranium mill tailings were used for construction of residence, shopping malls and other facilities and caused radiation levels to increase above normal background values ;

(2) Residential radon;

(3) Fall out due to atomic weapons tests; and

(4) Areas around nuclear facilities.

In Colorado the mortality rates for leukemia and all cancers excluding lung cancer rates is confounded by such other factors as cigarette consumption, occupational exposure to radon (many of the residents were miners) etc. For residential radon though some studies correlated the incidence of acute myelogeneous leukemia to indoor radon concentrations, the absence of a correlation for lung cancer, the only accepted cancer caused by radon, raises serious questions as to the causal interpretations of these correlations.

A number of atomic weapons tests were conducted at the Nevada Test Site which resulted in radioactive fallout to the surrounding areas. Increased childhood leukemia has been reported in these areas, though not without controversies. However, increase in incidence of overall leukemia and childhood leukemia is accepted as an ongoing case-control st dy of leukemia in Utah and might provide information on the causal nature of this association. As far as nuclear facilities are concerned, Office of Population Census and Surveys in Britain published in 1987, a report on cancer incidence and mortality in the vicinity of nuclear installations in England and Wales? There was no overall increase in cancer that could be linked to living near nuclear establishments, but a significant excess of leukemia mortality for young people under the age of 25 was noted. The reasons for this were not clear but it was concluded that radiation contamination or pollution was unlikely to be the cause of the increased rates around nuclear establishments in the United Kingdom, with the possible exception of Sellafield which is a nuclear fuel reprocessing plant. However, similar studies in the United States did not confirm any such correlation.

Dr Boice also describes the analytical studies, where exposure to individuals is known or estimated. One such study concerns indoor radon. Most of the investigations done in Sweden found a positive correlation. However, an investigation in Liaoning Province of China, perhaps the most polluted city in the world, after controlling for smoking and other measures of indoor pollution, lung cancer risks were not seen to vary with level of radon exposure.

In another analytic study, the risk of thyroid disease from lifetime exposures to increased levels of natural background radiation in South China was determined but no thyroid disease could be linked to living in the high background radiation areas. However, excess of chromosomal aberrations in circulating lymphocytes was found. But, the significance of these to carcinogenesis remains unclear.

For some years childhood leukemia cluster around Sellafield in the UK have been very much in the news. These were first reported in 1983 in a television programme and confirmed by a Government appointed committee chaired by Sir Douglas Black in 1984. In more detailed investigations it was determined that radioactive waste was unlikely to be the culprit but the occupational exposure of fathers of these children might be a causative factor. Later, UK government reports, the socalled COMARE reports concluded that environmental pollution from radiation seemed an unlikely explanation, although plutonium and americium discharges might be acting in an unsuspecting manner.

Dr Boice observes that the most provocative finding was the association between leukemia and preconception radiation of the fathers working at Sellafield. Risk was highest for children whose fathers received greater than 10 rem before their-children were conceived. Further exposure, 6 months prior to conception may have been most important, with highest risks for children whose fathers may have received greater than 1 rem in this period. Dr Boice discusses the odds against these findings and would like them to be replicated in other settings. Cancer clusters have also been reported around Dounreay, another nuclear fuel reprocessing plant.

Dr Boice adds a line of caution that low dose studies usually mean low-statistical power and imprecise estimates of risk, and chance events, either positive or negative, have a greater likelihood of being misinterpreted as meaningful than studies of high dose exposures.

Session III

8. Remedial Action Measures

D W Swindle, Jr

In giving background of the contamination of DOE sites, Dr Swindle talks of the dawn of nuclear age in 1940 with the Manhattan Project when relatively little was known of the measures needed to protect human health and safety for environments from the dangers posed by radioactive and chemical wastes. Further, the priority of that time were the demands of World War II, Korea and the Cold War. The result is that locations and magnitudes of these wastes at a number of sites are not known. DOE has now initiated a multimillion dollar cleanup programme for these contaminated sites.

The remedial action process has six phases viz. (1) preliminary assessment and site investigation, (2) maintenance and surveillance, (3) remedial investigation and feasibility study, (4) technology demonstrations, (5) corrective measures, (6) facility decommissioning or closure. The suggested remedial measures include (a) no action, (b) containment and (c) retrieval, treatment, storage and disposal.

It is also important to solve radiological assessment issues. There will be a level of risk that can be considered "clearly unacceptable". Risks occurring below the clearly acceptable level (1.0E-7—1.0E-4) should be considered trivial, warranting no further

investigation. Risks clearly above the unacceptable level (1.0E-3—1.0E-1), are to be avoided regardless of cost of remedial action. Risks occurring between there two extremes should be reduced as far as it is economically, socially and politically practical to do so.

There is a lesson in the DOE's problem of wastes; that constant attention should be given to wastes and not left entirely to future action. It may then become very costly or even intractable.

Session IV

Lauritson S Taylor Lectures in Radiation Protection and Measurements (Lecture no 14)

Radiation Protection and the Internal Emitter Saga

J Newell Stannard

L S Taylor lectures are delivered by eminent people who have worked and contributed significantly to the science of Radiation Protection and Measurements. Dr Stannard has contributed significantly in respiratory physiology and general biomedical research. He established the graduate education programme in the field of atomic energy as applied to health sciences which led to world's first PhD programme in radiation biology (as also health physics). He has very recently written a book, Radioactivity and Health : A History. This is a 2000 page volume which tells the fascinating story of scientific research and of the people who provided leadership and made important discoveries. You get a glimpse of this when you read Dr Stannard tell that "the internal emitter saga" began in the 14th century with the mysterious mountain sickness (Bergkrankheit) in the Erz Mountains of Central Europe which was identified with radon and radon daughter products through a very tortuous path. It may also be worth repeating that 55% of natural radiation dose comes from radon.

The first limits of exposure to Ra-226 were the result of direct approach i.e. measuring body burdens of residual radium in dial painters, radium patients, chemists and self-medicated individuals and finding a body burden associated with marginal change and reducing it by a safety factor. The second was the indirect (mixed) approach in which information from animal experiments is used to relate the effectiveness of the radionuclide in question to that of radium-226 called "Toxicity Ratio". This was then modified to take care of other factors like retention differences in animals and man. The above approaches, based as they are, could be applied to only very few radionuclides. For the hundreds of radionuclides the computational approach was the natural recourse and this led to the modelling of behaviour of radionuclides taken inside the body.

Dr Stannard also informs us that the importance of knowing environmental distributions and effects was apparent and work began even before the construction of the plutonium reactors at Hanford or any of the other major facilities. A whole new field, radioecology, has developed and has made enormous contributions to the problem of

radioactive fallout, effluent discharges, and waste disposal. Discussing internal dosimetry, Dr Stannard remembered the pioneers and the present day computer programmes which can generate a plethora of information. Nevertheless we have to ask regularly if the biological processes require all that. Then the question, "Dose to what?" has always tormented those who compute internal doses. Indentifying the target cell continues. We must continue to ask if the observed dose from a deposited radionuclide is biologically equivalent to the same dose from external sources as from nuclides with different characteristics. The answer is "generally yes" but there are exceptions, the most notable being I-131.

Panel Discussion

As is usual in panel discussions there was some divergence of opinion and some agreement. On public education and perception some people felt that one could talk to the public, or to individuals not from a high pedestal but at their level on equal terms, both learning something in the process. The other approach is to enlighten the skeptic elite and thereby in fluence the broader public because they (the skeptic elite) have much more access to the professional public communicators.

There was general agreement on the misleading and negative role of media. As far as media surveys are concerned, one has to be very cautious. These could be very misleading. The way questions are asked and then interpreted, one should very carefully figure out.

Session V

Summary

Alvin Weinberg

Dr Weinberg described the remedial measures as "..... the way a liberal democracy responds to technological hazard in this Age of Anxiety". Further according to him "..... many of the seemingly scientific issues fall into trans-science: questions isomorphic with answerable scientific question, but which for a variety of reasons are unanswerable in principle".

I would also like to reproduce here Dr Weinberg's quote from BEIR—V: "The possibility that there may be no risks from exposures comparable to external natural background cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero".

And lastly, "..... large scale use of radioactivity is necessary for meeting the most urgent human needs: individual health in medicine; and atmospheric health in the case of nuclear power to overcome CO2 accumulations".

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Many Atom Interactions in Solids (Springer Proceedings in Physics, Vol 48)
edited by R M Nieminen, M J Puska and M J Mannrinen
(Proceedings of the International Workshop, Pajulahti, Finland, June 5-9, 1989)
Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong Kong, 1990
viii + 319 pages, 117 figures, 22 tables; price; DM 98,00 (Hardcover); ISBN 3-540-52657-9

The dynamics of atoms in condensed matter is very important as it helps in explaining many physical properties and processes. At high temperature the classical Newtonian dynamics is applicable to the motion of the atoms to understand the physics of the system. The central problem is then to find the interactions between the atoms and forces acting on the atoms at any instant of time. Many scientists in this field have been successfully working for a long time to find out this interaction. But many more questions still remain to be answered. With a view to discussing these unanswered questions, an international workshop was held from 5th June to 9th June 1989 in Pajulathi, Finland. This book under review is the proceedings of this workshop. This workshop attracted a good fraction of the active groups in this field and their contributions have been grouped into review type articles and more specific application to different topics.

The book has been divided into four parts to help the readers to follow a systematic approach. Part I contains nine articles which deal with a general review of the subject as a whole. The first article introduces the many atom interactions in solids. Traditionally the interaction between the atoms have been described with pair wise interaction, the so called pair potential. A practical example taken from computer simulation is the Lennard-Jones potential valid for inert-gases only. For metals however Morse potential has widely been used although the pseudopotential theory is much more effective in tackling non transition metals. The article by Mannenen introduces to all these problems without going into much details of the interaction. The second article by V Heine and J Hafner is worth mentioning. The main purpose was to survey from a contemporary point of view, the existence of many atom interactions in solids and liquids. They trace the origin of these interactions through the tight-binding and nearly-free-electron theory and bring some sort of glue model to calculate the total energy. They also bring the bond picture of Pauling to explain the overall picture of the solid and the liquid.

The description and understanding of bonding in metallic system has improved considerably in recent years with the development of density functional theory. The electronic-structure problem is tremendously simplified with the treatment of the exchange and correlation problem in the local density approximation and this has made possible very accurate large-scale calculations of structural properties of many metallic systems. Alongside with the improvements in these "*abinitio*" methods the development of a more approximate and at the same time simpler effective medium theory of bonding has taken

place. The effective medium theory is also based on density-functional theory. The article by K W Jacobson deals in detail this effective medium theory.

The next article is by M S Daw who brings the embedded atom method. This method has become a popular replacement for interatomic pair potential in total energy calculation of metallic systems. This method relates the embedding energy of an atom in an electron gas to the cohesive energy of a metallic solids. This method is also derived from the density functional theory.

The rest of the articles are more or less specific application to actual systems such as metals and semiconductors.

Part II deals with metals. Here also all the the above theories have been applied. Part III deals with semiconductors and covalent materials. Lastly in Part III some surface phenomena is described. These contain some computer simulation with environment-dependent effective pair potential.

The book has attempted to give a picture of modern theories of many atom interactions in solids. As with all proceedings of workshop and symposium, this book also suffers from detail derivation and discussions so that this is not suitable for BSc and MSc students. This is however a very good addition to research students, working in this field. I feel that all scientific libraries and research groups working in this line should possess a copy of this book.

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Particle Physics and Inflationary Cosmology (Contemporary Concepts in Physics, Vol 5)
by Andrei D Linde
(Translated from the Russian by M Damashek)
Harwood Academic. New York, 1990
362 pages, price $ 60.00 (Hard cover); ISBN 3-7186 0489-2

The theoretical research on the cosmological evolution has undergone a big change in the last two decades—particularly in view of the new ideas like inflationary cosmology and the phase transitions at the early stage of evolution of the universe. As remarked by Prof Linde—the author of this book, the universe is not only the poor man's accelerator, but is now the only accelerator that could ever produce particles at sufficiently high energies to test the unified theories of all fundamental interactions.

The book 'Particle Physics and Inflationary Cosmology' by Linde is an excellent

monograph of Inflationary Cosmology and its deriect relations with the contemporary ideas of particle physics at the beginning of the evolution. In the original version of Guth the scalar field at GUT epoch mediates symmetry breaking from the symmetric SU(5) vacuum to the SU(3)× SU(2)×U(1) broken symmetry vacuum. But in this scenario, the bubbles formed could not join up and thus the universe would be left in a very nonuniform state. Andrei D Linde, the author of this book, himself proposed in 1981 the new inflationary scenario, in which any quantum fluctuation of the field would have slow rolling down finally to the true vacuum while inflating. The long plateau in the potential curve gives enough time for a single fluctuation domain to inflate to a scale much bigger than our observable universe. It thus avoides the inhomogeneity problem in addition to those taken care of in Guth's original version—such as fine tuning, flatness problem, the magnetic monopole problem etc. This new inflationary theory was criticized by Stephen Hawking, who along with Ian Moss put forward an alternative proposal that the phase transition was triggered by a homogeneous Higgs field via tunnelling of the universe as a whole. As for the galaxy formation problem, the new inflationary model would have difficulties. It would require density fluctuation of the amplitude too-large compared to the derived observational value. Later in 1983 Linde himself suggested an improved version—the 'Chaotic Inflationary model' where it was assumed that the present state of the universe could have arisen from quite a large number of different initial configurations and the evolution would take place from a chaotically distributed scalar field. Thus there would be no phase-transition or supercooling. This book has an elegantly-written long introductory chapter giving an overview of the unified theories of elementary particles and the inflationary scenario followed by nine more chapters discussing in-depth topics like spontaneous symmetry breaking, phase transitions, general principles of inflationary cosmology—its different scenarios and lastly, the relation of the phenomenon of inflation with Quantum Cosmology. The other models such as chaotic inflation in the background of Supergravity, the modified Starobinsky model and the inflation in Kaluza Klein and Superstring theories are also given in sufficient details in the Chapter 9. In relation to the singularity problem, it is argued that the same inflationary scenario implies on the largest scales an absolutely inhomogeneous universe. Hence, there is presently no compelling basis for maintaining that there is a unique beginning or end of the universe as a whole. There is an illuminating discussion on them in the last chapter.

Many details of the inflationary scenario are changing with the rapidly changing ideas of elementary particle theories. There are even doubts expressed by a section of relativists about the credibility of such a model because there is a question if the vacuum energy stress tensor would always lead to the de Sitter form if the universe be originally in a general anisotropic form. However, the thorough and systematic accounting of the progress of the inflationary scenario upto the present time done in this exposition by one of the leading exponents in this line would surely help any serious reader to be able to attain a fairly complete and accurate understanding of the present status of the subject and to

contribute to its future development. The long list of 361 references at the end of this book is quite exhaustive and will be really useful to a more involved worker in this branch.

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Renormalisation and Asymptotic Expansions (Progress in Physics, Vol, 14)
by V A Smirnov
Birkhauser-Verlag: Basel-Boston-Berlin, 1991
392 pages, price: sFr. 98-/DM 118.-; ISBN 3-7643-2640-9

The book under review is an elaborate treatise on the formal aspects of renormalisation theory. It is not meant for beginners but may turn out to be valuable for those who have a basic grounding in renormalisation theory.

Chapters 1 and 2 serve a well-intentioned introduction to the fundamental aspects of Feynman amplitudes viz. ultraviolet (UV) and infra-red (IR) divergences and the parametric representation of Feynman amplitudes. The treatment is interesting because the author starts straight away by looking at Feynman amplitudes from the perspectives of graph theory while the physical theory corresponding to a graph is stressed implicitly. By looking at Feynman amplitudes as tempered distributions, the author is able to bring out the similarities of the UV and IR properties of the amplitudes.

The convergence of Feynman amplitudes (regarded as tempered distributions) are dealt with in Chapters 3 and 4. In this context, the factorisation of amplitudes are discussed purely from the standpoint of graph theory. Here some discussion on the physical aspects of factorisation may not have been out of place.

Chapter 5 discusses dimensional regularisation and this is used in Chapter 6 for the evaluation of Feynman integrals. The discussions on the Gegenbauer polynomial x-space technique and symmetries and combinatorics of Feynman graphs are from a refreshing new angle. Chapter 7 is devoted to analysing the singularities of Feynman amplitudes.

Part 2 of the book (Chapters 8-12) describes the formal machinery of renormalisation. The author has rightly based this discussion on dimensional regularisation and Zimmerman's forest formula has been discussed in this light. The BPHZ-scheme and $\hat{R}$ R^* operations and all other nuances of renormalisation theory have been well covered.

Asymptotic expansions constitute Part 3 of the book (Chapters 13-16). As before, the formalism is set up with regorous proofs at the beginning of Chapter 13 while the explicit calculational aspects are descirbed in the latter part. Subsequent chapters deal with

operator product expansions and the techniques are well illustrated with direct application to QCD problems.

Considering the scope, the book is very concise and comprehensive and is a good addition to the literature on renormalisation theory.

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Lectures on String Theory (Lecture Notes in Physics, Vol. 346)
by D Lüst and S Theisen
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The book is written by Dieter Lüst and Stefan Theisen, leading researchers in string field theory and high energy physics of European Centre of Nuclear Research, CERN, Geneva. The book contains, a good introduction to the present days fascinating fundamental subject: The Superstring Theory, which is designated by many scientists as the Theory of Everything (TOE). The book is very topical and also gives some details of the last ten years' discoveries for the construction of superstring field theories. This text-book is an update presentation of the subject together with the citation of relevant important references in the subject. It is well-presented and self-contained and an important addition to the standard reference book; "Superstring Theory" Vol-I and II and John Schwartz, Mike Green and Ed Witten (Cambridge University Press; 1987) and text-book like "Introduction of Superstring" by M Kaku (Springer-Verlag; 1988). Therefore, this text-book should be appreciated and be helpful to both newcomers and existing researchers in this field as well as to the MPhil and PhD students in this subject.

The book contains some fifteen chapters. The beauty of the book is that it covers the subjects in some details in 346 pages from the introduction of bosonic string to its quantization, conformal and superconformal field theory, BRST quantization, string perturbation theory, fermionic string and its quantization, compactification and 10-dimensional and 4-dimensional heterotic string, Kac-Moody algebras, bosonization of fermionic string and low energy field theory.

With a short preface of the subject in Chapter 1, the book deals with bosonic string in Chapters 2 and 3. In bosonic string, the discussions of Nambu-Goto and Polyakov action and the light-cone quantization, path integral quantization and operator quantization are presented.

The conformal field theory, BRST quantization and string perturbation theory are

described vividly in Chapters 4,5 and 6. The conformal field theory and Virasoro algebra as developed by Polyakov and others and BRST treatment of string theory are presented in detail in Chapters 4 and 5. The important aspect of perturbation theory of closed oriented bosonic strings is one of the important subjects of Chapter 6. This aspect is described at length, which was mainly developed in the mideighties by Alvarez and others as the theory of strings with boundary fluctuations, topology and quantum geometry with the inclusion of the loop graph and the tube model.

In the next phase of the book, the fermionic string is discussed in Chapters 7 and 8. The formulation of fermionic string by Schwartz and so-called Green-Schwartz formalism of superstring and the quantization of fermionic spining string are presented. The special aspect of Chapter 9 is the spin structure, theta functions and modular invariance in string theory.

Chapters 10 and 11 are devoted for the stimulating discussions of the compactification of closed bosonic string, Kac-Moody algebra and 10-dimensional heterotic string.

The superconformal field theory, the covariant quantization of superstring theories and spinor field of Ramond-Neveu-Schwartz model have been studied exclusively in Chapters 12 and 13.

In chapter 14, the book presents the supersymmetric heterotic string theory in 10- and 4-dimensions. The compactification of closed string on torus and compactification of 10-dimensional heterotic string theory are given. The 4-dimensional Minkowski space-time co-ordinates are uncompactified, whereas the remaining 6-dimensions are curled up, say by Calabi-Yau manifolds and the Scheme of vacuum configurations for superstring are also described.

Chapter 15 deals with the aspects of low energy field theory of strings. The string theory is claimed to be an unifying framework for the description of all fundamental particles and their interactions; hence, a discussion on strings in arbitrary back ground fields and the effective field theory from quantized strings is a relevant presentation for the projection of future researches in the unification of fundamental forces.

The book is a nice venture by the authors in collecting the important aspects of string theory and an important addition to the researchers in field theory, particle physics and quantum gravity physics. The book is certainly to be a welcome volume to any library of physics and to be very useful as a personal collection for the physicists interested in string theory.

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